TAP 502-2: Photoelectric effect questions

$hf = \phi + (1/2)\, mv^2$ and $hf = \phi + eV_s$

$e = 1.60 \times 10^{-19}$ C,

$h = 6.63 \times 10^{-34}$ J s,

mass of electron $= 9.11 \times 10^{-31}$ kg

1 The work function for lithium is 4.6×10^{-19} J.

(a) Calculate the lowest frequency of light that will cause photoelectric emission.

(b) What is the maximum energy of the electrons emitted when light of 7.3×10^{14} Hz is used?

2 Complete the table.

Metal	Work Function /eV	Work Function /J	Frequency used /Hz	Maximum KE of Ejected electrons /J
Sodium	2.28		6×10^{14}	
Potassium		3.68×10^{-19}		0.32×10^{-19}
Lithium	2.9		1×10^{15}	
Aluminium	4.1			0.35×10^{-19}
Zinc	4.3			1.12×10^{-19}
Copper		7.36×10^{-19}	1×10^{15}	

3 The stopping potential when a frequency of 1.61×10^{15} Hz is shone on a metal is 3 V.

(a) What is energy transferred by each photon?

(b) Calculate the work function of the metal.

(c) What is the maximum speed of the ejected electrons?

4 Selenium has a work function of 5.11 eV. What frequency of light would just eject electrons? (The threshold frequency is when the max KE of the ejected electrons is zero)

5 A frequency of 2.4×10^{15} Hz is used on magnesium with work function of 3.7 eV.

(a) What is energy transferred by each photon?

(b) Calculate the maximum KE of the ejected electrons.

(c) The maximum speed of the electrons.

(d) The stopping potential for the electrons.

Answers and worked solutions

1(a) $hf = \phi$

$hf = 4.60 \times 10^{-19}$

$f = 4.60 \times 10^{-19} / 6.63 \times 10^{-34} = 6.94 \times 10^{14}$ Hz

(b) $hf = \phi + (1/2)\, mv^2$. $(6.63 \times 10^{-34} \times 7.30 \times 10^{14}) = 4.60 \times 10^{-19} + (1/2)\, mv^2$

$4.84 \times 10^{-19} - 4.60 \times 10^{-19} = (1/2)\, mv^2 = 0.24 \times 10^{-19}$ J

2

Metal	Work Function / eV	Work Function / J	Frequency used / Hz	Maximum KE of ejected electrons / J
Sodium	2.28	3.65×10^{-19}	6×10^{14}	0.35×10^{-19}
Potassium	2.30	3.68×10^{-19}	6×10^{14}	0.32×10^{-19}
Lithium	2.90	4.64×10^{-19}	$1. \times 10^{15}$	1.99×10^{-19}
Aluminium	4.10	6.56×10^{-19}	1.04×10^{15}	0.35×10^{-19}
Zinc	4.30	6.88×10^{-19}	1.2×10^{15}	1.12×10^{-19}
Copper	4.60	7.36×10^{-19}	1×10^{15}	0

For copper 1×10^{15} Hz is below the threshold frequency so no electrons are ejected.

3

(a) 1.07×10^{-18} J

(b) $hf = \phi + eV_{s,}$ so $\phi = hf - eV_{s,\,so}$ $\phi = 1.07 \times 10^{-18} - (1.6 \times 10^{-19} \times 3) = 5.9 \times 10^{-19}$ J

(c) $eV_s = (1/2)\, mv^2$ so $(1.60 \times 10^{-19} \times 3) = 0.5 \times 9.11 \times 10^{-31} \times v^2$

so $v^2 = 1.04 \times 10^{12}$ and $v = 1.02 \times 10^6$ m s^{-1}

4 1.2×10^{15} Hz

5

(a) 1.6×10^{-18} J

(b) $(1/2)\, mv^2 = 1.x \times 10^{-18}$ J

(c) $v^2 = 1.1 \times 10^{12}$ so $v = 1.1 \times 10^6$ m s^{-1}

(d) $eV_s = (1/2)\, mv^2$ so $eV_s = 1.00 \times 10^{-18}$ and $V_s = 0.63$ V